Promoting Standards through Use Cases

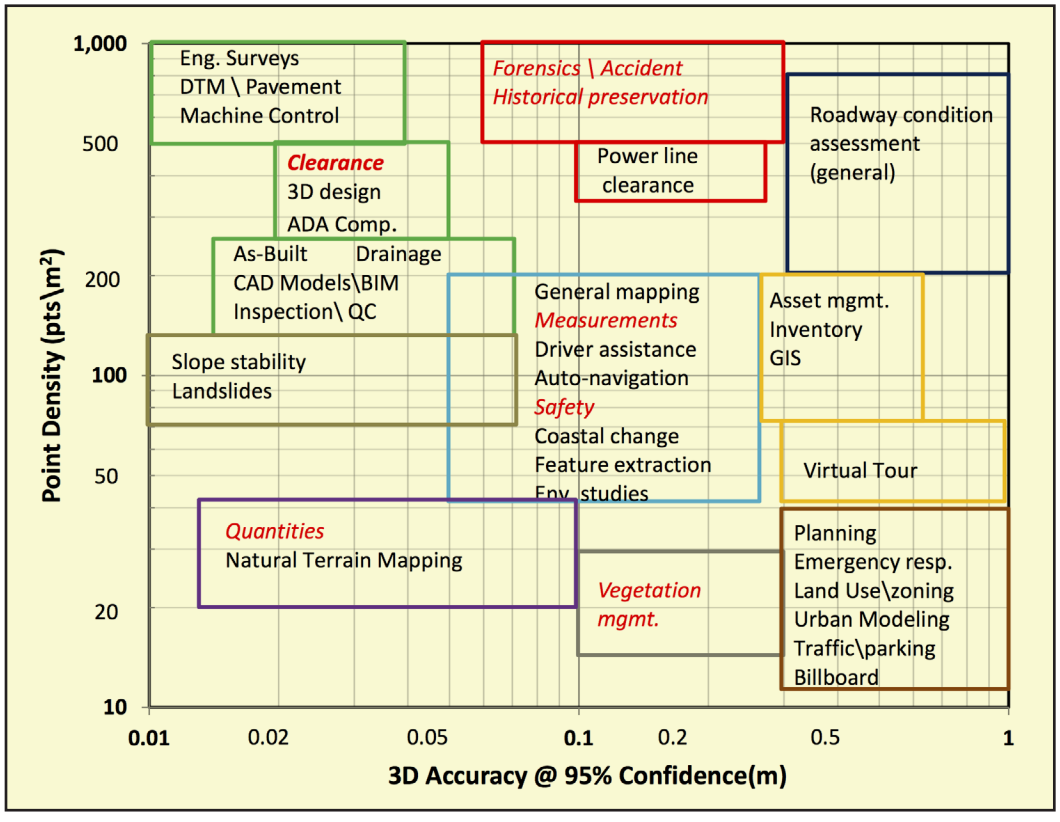

Figure 1: Figure 10 from (NCHRP) Report 748 by the TRB

In this article I want to explore what I believe is a missing piece of the adoption of standards and more generally a barrier to greater growth in the mobile lidar mapping segment. First I'll present the issue from the point of view of someone outside the lidar mapping industry. Then I'll demonstrate a solution by applying mapping guidelines and documenting the results using the Optech Lynx mobile mapping system.

Imagine that you are a project manager for a municipality and need to take a 10-mile urban arterial street rehabilitation project from conceptual engineering to final design. There is a lot of pressure to get the project out to bid quickly because the window for securing funding is closing and it might be years before a new funding opportunity arises.

The first activity in the critical path is to obtain survey-grade mapping of the project area in order to facilitate the final design and quantity take-off so the project can go to bid. You consult your list of prequalified service providers and solicit a short request for proposals (RFPs) and interviews.

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To meet the timeline constraint, you estimate that the survey must be completed and delivered to your design engineering consultant in a minimum of 4 weeks, but upon reviewing the RFP responses the project seems unfeasible. The first problem is that the maintenance of traffic and closure permit to get surveyors on the street safely will add at least a week to your schedule before boots are on the ground. Add in the cost of traffic control and your budget starts getting a little too tight. None of the consultants interviewed can provide a standard surveying solution that meets your needs.

As you rack your brain and review your notes from the interviews, you remember that one of the surveying consultants mentioned an alternative that could complete the project on your timeline: mobile LiDAR mapping technology. You initially dismissed the idea because those services have never been used in your agency. How would you contract for those services? The idea was full of risk from your perspective.

But then you remember the *LiDAR News* blog you subscribed to a few years ago. A quick web search and a few reviews of some articles and you start to believe that maybe that consultant could be right. So how do you sell your manager on the idea that mobile mapping is right for this project? There is no standard of practice to go by because it's never been done here before. How can you get around the "Great, but not on my project" trap?

A bit more searching of the *LiDAR News* archives and you find several posts on standards and guidelines. That could help. If only you could find some information or case studies that show that the guidelines were effective and easily adopted. You continue to search hoping to find examples of guidelines being applied and successful results being reported, but alas, you come up with nothing.

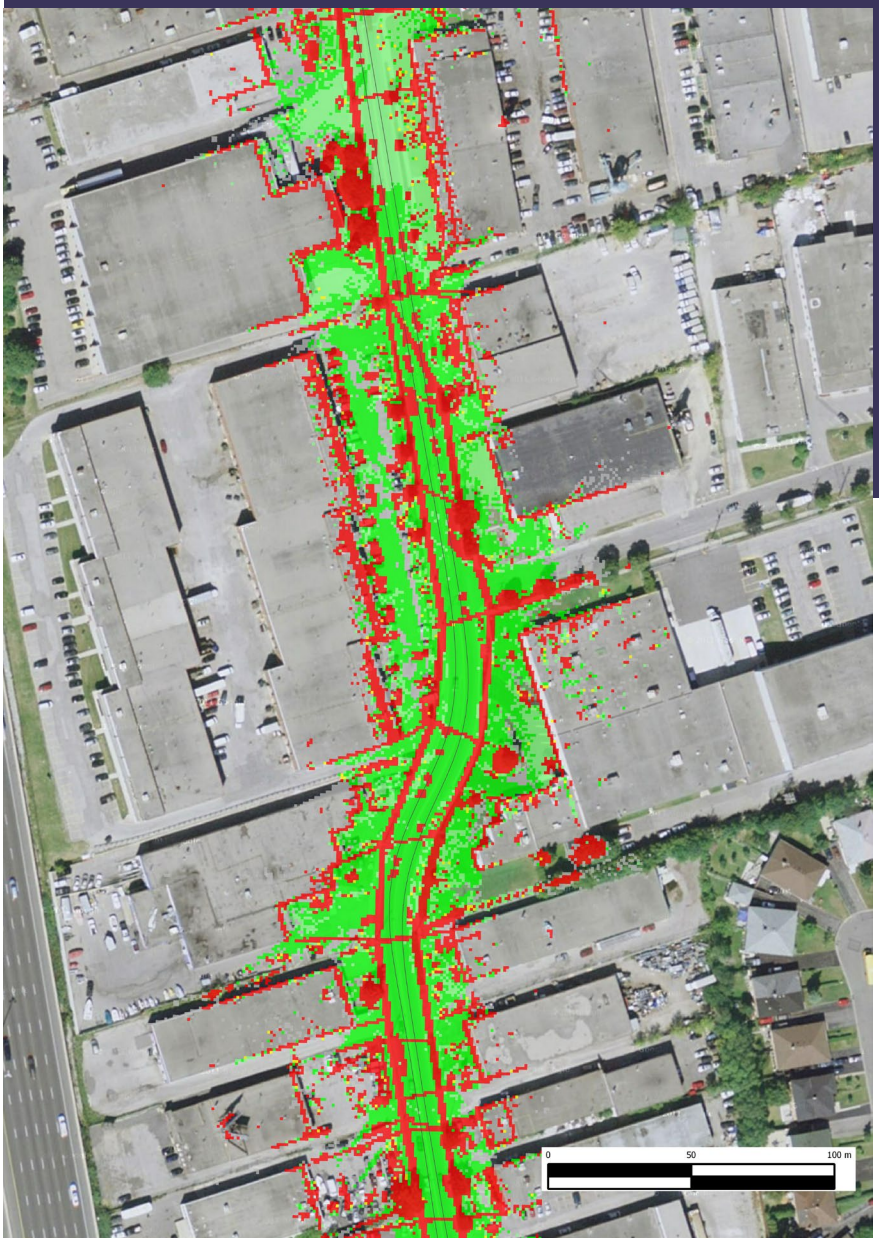

Figure 2: Height difference map

I believe this little hypothetical story hits pretty close to home. A lot of effort has been exerted to develop standards and guidelines, but I don't think we as an industry have done enough work to implement them in order to clearly communicate how mobile LiDAR mapping can be an effective solution to the sort of problem outlined above.

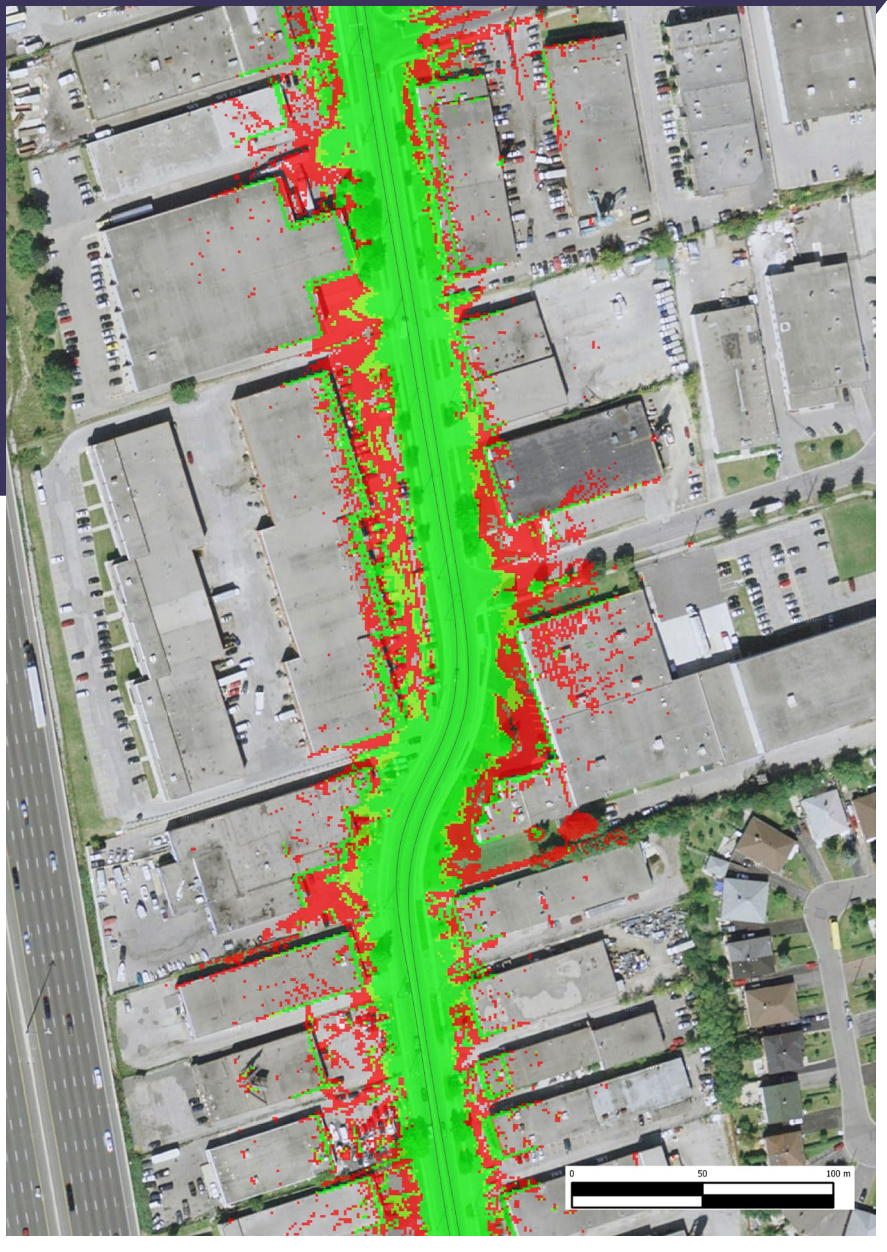

Figure 3: Lidar point density map

I strongly believe that performance-based specifications are superior to prescriptive or procedural standards. One of the many benefits of performance-based specifications is that service providers are free to be innovative as long as they can meet the specification requirements of the work. In this environment, the service provider is driven to be as efficient as possible and add value to their proposal to differentiate themselves from other consultants.

As an example, I'm going to show how to use National Cooperative Highway Research Program (NCHRP) Report 748, a guideline created for the Transportation Research Board (TRB), to describe a performance-based mapping specification. Then I'm going to demonstrate how the Optech LMS Lidar Mapping Suite Professional software can clearly prove that the data collected by an Optech Lynx SG-1 Mobile Mapper™ complies with the mapping specification as a natural outcome of the LMS Pro workflow.

The TRB specification provides a simple method to specify accuracy requirements for a mobile mapping project, even if you've never seen a mobile mapping project before. All you need to do is establish the coverage, required point density, and mapping accuracy for your project.

The coverage is used to determine the limits of what is required to be mapped, which is necessary to define the survey scope but insufficient to define the mobile mapping specification. To help define the sufficient requirements for mobile mapping, the TRB guidelines[1] provide a chart, reprinted here as **Figure 1**.

In the hypothetical case above, we need an engineering grade survey. Based on the TRB selection matrix, I know I need 500-1000 points/m^2 and a 3D point accuracy of 0.01-0.05 cm at a 95% confidence interval. I don't have an exact specification, but I have enough that I can work with my consultants to determine what values would work best for this application.

With the coverage defined and the technical approach and mapping criteria negotiated, we agree that the mobile survey must perform to the following criteria:

- Accuracy ≤0.050 m with respect to the survey network (N specification)
- Accuracy ≤0.050 m with respect to relative accuracy (L specification)
- Density ≥200 points/m^2 (D specification)

Using the conventions of the TRB guidelines, the specification is clearly communicated as follows: **N-0050-L-0050-D-0200 per NCHRP Report 748 Chapter 12**. The mapping service provider now has all the information required to plan the work and estimate the fee.

In this hypothetical example, if procedural specifications for data collection and survey control procedures were used, the project would not have been able to proceed because the agency did not have an incentive, time, or budget to investigate, develop and publish a quality specification. The agency would also not be able to benefit from any innovation in mapping technology until they could review and update the procedures. Exceptions would have to be made on a contract-by-contract basis in the interim.

With the requirements specified, we can move on to project planning and execution. I need to mobilize the mobile mapper while the ground control survey is happening to meet the scheduling requirements. The first innovation I can use to my advantage is that Optech LMS Pro uses point-to-plane and plane-to-plane geometric constraints. As a result I don't need to place lidar targets in the scene before I collect data.

The second innovation I can apply is LMS Pro's relative lidar block adjustment, which lets me validate coverage, point density, and local accuracy before ground survey is complete. Specifically, the height difference map enables users to validate the coverage, calibration, and local accuracy in LMS Professional or a third party viewer (**Figure 2**), while the point density can be validated using the point density map (**Figure 3**).

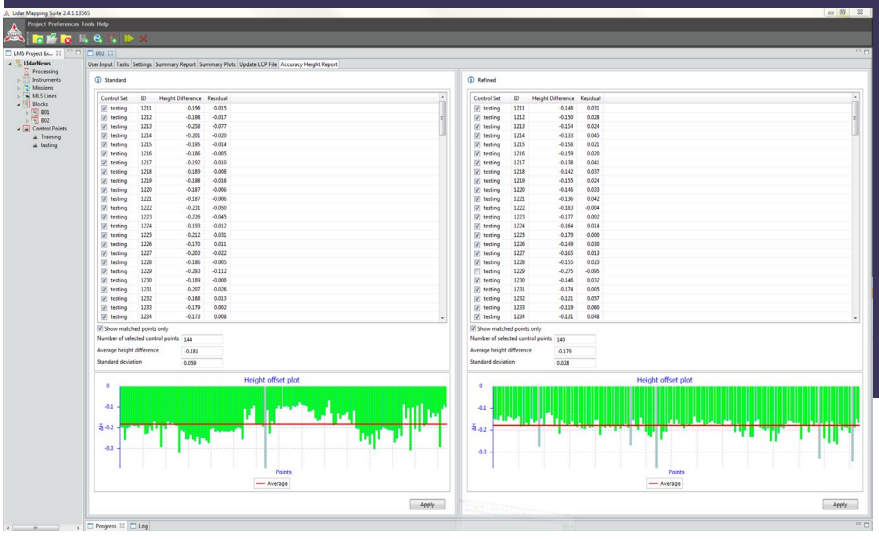

Figure 4: Table of validation points to point cloud results

All that is left is to validate the point cloud accuracy with respect to the survey network. I divide the ground control points into two data sets. The first set is the training data file, which is used to constrain the final lidar block adjustment. The second set is the test data file, which is used to validate the point cloud accuracy with respect to the survey control network. LMS Pro uses these additional inputs when computing the final constrained lidar block adjustment. The testing data results are presented in a table of variances and two summary statistics: the mean variance of the distance from the test points to the point cloud and the associated standard deviation. An example is shown in **Figure 4**.

With this data and knowledge in-hand, a service provider has all the documentation necessary to demonstrate that the lidar data has met the mapping specification as a direct result of using the tools built into LMS Pro, and they are now free to extract the vector features from the point cloud to deliver to their client.

In summary, performance-based specifications benefit both owners and sevice providers: Owners can contract for mobile mapping services without an expensive investigation of the technology, while service providers, thanks to some forethought in their tools and equipment, can prove to their client that the project meets specification without a lot of extra work.

References

[1] M. Olsen et al, "NCHRP Report 748 Guidelines for the use of Mobile LIDAR in Transportation Applications," Transportation Research Board of the National Academies, 748, 2013.

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